OPTIMIZATION FRAMEWORK FOR TRANSPORTATION IN MANUFACTURER COMPANY

ARTHIT CHAROENPITAKCHAI

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Thematic Paper
entitled

OPTIMIZATION FRAMEWORK FOR TRANSPORTATION IN MANUFACTURER COMPANY

……..……..……
Mr.Arthit Charoenpitakchai
Candidate

……..……..……
Lect. Benjalux Sakunasingha, D.B.A.
Major advisor

……..……..……
Asst. Prof. Toryos Pandejpong, Ph.D.
Co-advisor

……..……..……
Asst. Prof.Auemphorn Mutchimwong, Ph.D.
Acting Dean
Faculty of Graduate Studies
Mahidol University

……..……..……
Lect. Ornlatcha Sivarak, Ph.D.
Program Director
Master of Business Administration
Program in Business Modeling and Analysis
International College
Mahidol University

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on
September 24, 2012

……
Mr.Arthit Charoenpitakchai
Candidate

……
Lect. Phannaphatr Savetpanuvong, Ph.D.
Chair

……
Asst. Prof. Toryos Pandejpong, Ph.D.
Member

……
Lect. Benjalux Sakunasingha, D.B.A.
Member

……
Asst. Prof.Auemphorn Mutchimwong, Ph.D.
Acting Dean
Faculty of Graduate Studies
Mahidol University

……
Prof. Maleeya Kruatrachue, Ph.D.
Dean
International College
Mahidol University

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Arthit Charoenpitakchai

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ARTHIT CHAROENPITAKCHAI 5338749 ICMA/M

M.B.A. (BUSINESS MODELING AND ANALYSIS)

THEMATIC PAPER ADVISORY COMMITTEE : BENJALUX SAKUNASINGHA, D.B.A., Asst. Prof. TORYOS PANDEJPONG, Ph.D.

ABSTRACT

The purpose of this thematic paper was to create an optimization framework for transportation in a Manufacturing Company. The optimization framework is a step by step guideline for a Manufacturing Company in order to achieve a better performance on the transportation system. The optimization framework was developed from a generic modeling framework process with optimization method. There is an empirical example showing the steps of using the optimization framework for transportation. From the case, the new model developed from the adapted framework created a good improvement for the company's KPI in transportation system. To sum up, there are six-steps of optimization framework for transportation in Manufacturer Company that were proposed in this research.

KEY WORDS: OPTIMIZATION / TRANSPORTATION / FRAMEWORK / MODEL DEVELOPMENT / LINEAR PROGRAMMING

66 pages

แผนผังการพัฒนาการขนส่งสำหรับโรงงานผู้ผลิตสินค้า

OPTIMIZATION FRAMEWORK FOR TRANSPORTATION IN MANUFACTURER COMPANY

อาทิตย์ เจริญพิทักษ์ชัย 5338749 ICMA/M

บธ.ม. (การวิเคราะห์และการสร้างตัวแบบธุรกิจ)

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บทคัดย่อ

การศึกษาครั้งนี้เป็นงานวิจัยเพื่อการ สร้างแผนผังการพัฒนา สำหรับ ระบบการขนส่งสินค้าสำหรับบริษัทผู้ ผลิตสินค้า แผนผังการพัฒนาจะแสดงขั้นตอนการพัฒนาให้กับบริษัทผู้ผลิตสินค้าเพื่อที่ประสิทธิภาพระบบการขนส่งดีขึ้น แผนผังนี้พัฒนาจากแผนผังระบบงานทั่วไปด้วยการหาวิธีการพัฒนาที่เหมาะสม ในงานวิจัยนี้ได้ทดลองพัฒนาระบบขนส่งให้ กับตัวอย่างบริษัทหนึ่ง ผลปรากฏ ว่า สามารถพัฒนาประสิทธิภาพการขนส่งให้ดีขึ้นได้ดี ดังนั้นแผนผังการพัฒนาการขนส่งสำหรับบริษัทผู้ผลิตสินค้าได้ถูกนำเสนอขึ้นในงานวิจัยนี้

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CHAPTER I
INTRODUCTION

1.1 Introduction

Business that can prevent loss or reduce cost would gain competitive advantage over others, and this is more important for the manufacturer perspective. One of the major loss expenditure is caused by transportation. The lower loss in transportation expense compare to the competitor can create competitive advantage as well. Approaching in loss reduction can be executed by optimization. Many researches demonstrated various optimization methods such as linear programming, goal programming and non-linear programming. However, this research attempted to develop the generic optimization framework for transportation in Manufacturer Company. The case study will be an optimization example developed by this research framework.

1.2 Purpose and Objective of Study

The purpose is to develop the optimization framework for transportation and use it as a tool to help delivery manager or responsible delivery service to achieve a better performance in transportation for Manufacturer Company. The optimization framework for transportation also can be flexibly applied to any manufacturer company who has their own delivery department. The framework must be valid and practical.

1.3 Scope of the Study

The framework of this research was developed from generic framework process. There are several optimization methods which are included in the framework such as linear programming, goal programming, integer programming, and optimization software.

1.4 Limitation of the Study

The optimization framework can be applied only for Manufacturer Company which is in perfect competition business only. It still cannot apply to monopoly and oligopoly business. It can be further developed for other business type such as Logistics Company, Distributors, E-Commerce Business, etc. There are other optimization methods which are not raised up in this research such as Non-Linear Programming, Queuing Theory.

1.5 Contribution

The benefit of this research is that the framework can be used and applied to companies who are interested to use it as their tools for improving transportation. The framework will be valid and ready to use. It can be applied in manufacturing sector in general. With this optimization framework, it can create the competitive advantage for Manufacturer Company. It also can improve the efficiency of energy for transportation energy consumption.

CHAPTER II
LITERATURE REVIEW

This chapter would discuss about the literature review. The past researches which discussed about management, optimization method, and transportation optimization example.

2.1 Management

2.1.1 Manufacturer Business Categorization

Lederer & Li(1997) introduced the paper research about the pricing, production, scheduling, and delivery-time competition between firm that produce goods and services. Their research focused on the customers who were sensitive to delivery delay time. For the global competition, delivery and service timing were called response time. The better of timing strategy would deceive the more shared market, higher price and lower cost. Their study focused on the two type of firm in market. They were perfect competition and monopoly.

Perfect Competition business firm who would fight on the lower cost and faster delivery time with similar selling price. The loss from delay time could be considered as opportunity cost. They introduced the full price formula for perfect competition firm as follow formula.

$$\text{Full Price}(z) = \text{price} + \text{Delay Cost}(z)$$

Where z is the cost for any extra delay time per time and unit

The delay cost was an incur cost for perfect completion firm type which they also could include in their full price. The delay cost function considered the response time. The extra unit time for delivery increased the delay cost of the product. So the formula demonstrated that full price could refer to sum of actual price charged and the expected delay cost.

Monopoly and Oligopoly business firm who used time-based strategy competition. They would earn extra charge from customer for faster service. Lederer & Li (1997) said "The fast delivery and charges a premium for fast response". These mean that the firm could earn profit from selling product and gained more on extra charge on express service.

On the other hand, any firm had different problem and different character. So it was quite difficult to generate the equilibrium outcome. There was also company incentive for customer.

2.1.2 Transportation Concept

Cooley (1894) gave the concept of the transportation that was the movement of objects. They could be single or mass. They were delivered from first place to other place. The accomplished point of transportation which considered as the best solution were shortest time, speed and cheap. In addition, they must be reality as very first fundamental.

2.1.3 Modeling Framework

Albright & Winston (2007) introduced the seven steps for modeling process framework as figure 2.1.

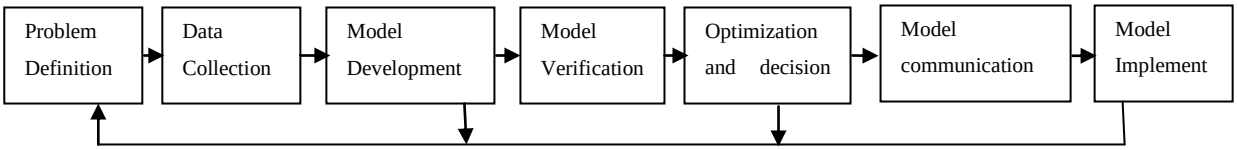


Figure 2.1 Flowchart for the Seven-Step process

Source: Management Science Modeling, Albright & Winston (2007)

2.1.3.1 Problem Solving

This part must define the problem from organization. Which was the real problem to solve? It could be minimizing cost, maximizing profit.

2.1.3.2 Data Collection

After defining the problem, the analyzer should find the data what to collect to estimate the value of parameters that were involved with the problem. Sery, Presti & Shobrys (2001) used data aggregation for BASF transportation research to categorizing parameters after collecting to data.

2.1.3.3 Model Development

There were many analytical models. The model was suitable to apply by understanding the objectives, problems, and data that collected. Then there would be the suitable model to formulate. It could be mathematical model as common use.

2.1.3.4 Model Verification

After analyst generated the feasible solution from model, it must test the result with the real outcome in order to verify the correct model. This process was to check the accuracy of the model. Albright & Winston (2007) suggested the analyst that model verification could be done by observed the duplicated situation. The model's input parameters needed to be exactly same as the current parameters. The model's output should be in line with the output observed. Moreover, second way to verify the mode was whether the outputs from the model were *reasonable* or the output had to be as *expected*. Saul (1982) said the model would be valid when it was satisfied with the result or output of the model. Also it needed to do statistical test and sensitivity analysis. The model would be never fully completed validity, unless there was a real input data.

2.1.3.5 Optimization and Decision Making

The model showed the feasible solution and recommended the optimal one. The analyst had to choose the decision that was the best and meet organization objective. Balakrisnan, Render & Stair (2007) said the developed model or any new procedures might could not solve the problem or give the optimal result. If the model was too big or too complex, they called heuristic approach. The heuristic was the method to solve by trial and error to meet the goal. However, it might not be an optimal solution.

2.1.3.6 Model Communication

It was time for analyst to show the recommended solution to the decision maker and organization. Some change that effect other people or department benefit might need to negotiate the trade off outcome. The successful of communication must involve key people. It should not communicate only at the end of modeling process. It should occur while it was in the modeling process through the end. The analyst should present the user-friendly model. It could help on communication for the new model proposed.

2.1.3.7 Model Implementation

Demonstrate the model to the client. It needed to convince with the real value for people who needed to use it. Successful implementation came from the appropriate input and the management accepts the model. Albright & Winston (2007) said the analyst built the complex mathematic model, however, other people did not understand. It needed to show how it worked. Many potential models were perfectly correct, even though they were never implemented.

Stephen & Kenneth (2009) said that the modeling allows us to make inexpensive errors. Modeling could simulate the propose idea and tested within the model. It also could explore some unconcerned variables. Stephen & Kenneth (2009) introduced six-stage problem-solving process. They were exploring the mess, searching for information, identify a problem, searching for solutions, evaluating solutions and implementing a solution.

2.1.4 Suitability of Management Model

Souder (1972) said that there were five main criterions to evaluate the suitability of management model. They were realism, flexibility, capability, ease of use and cost. These were criterions for project selection. The rating system also could be used for project selection decision making. Profitability Index was the general one scoring type for ease of use. The linear and non-linear models were also generally high flexibility.

2.2 Optimization Method

2.2.1 The Linear Programming

Dantzig B. George (1963) who was the founder of the linear programming. Dantzig (1963) said "Linear Programming was concerned with the maximization or minimization of a **linear objective function** in many variables subject to linear equality and inequality **constraints**. He said, the mathematical linear programming equation that was built up in order to find the satisfaction with minimize and maximize satisfaction. The satisfaction could represent in vector-matrix notation with possible upper bound and lower bound on each variables. He had also demonstrated the housewife's problem to be example of linear programming problem. The housewife needed to plan the food for her family. Her variables in this problem were price of foods, calories, proteins, fat, carbohydrate and vitamins. The constraints were limited of price of foods, calories minimum on children and maximum on her husband. This linear programming was to find the food combinations in order to minimize the food expense which considered as objective of linear function. Some of food combinations were feasible but it was not minimizing the food expense.

Linear programming would now short call with "LP". LP problems could be varying from small to large. The small on was the problem with constraint lower than 1000. The number of constraints which was more than 1000 could be considered as large LP. In order to solve large LP, it required special software. Albright & Winston (2007) wrote about the spreadsheet optimization was the one of tools to create quantitative analysis with linear programming (LP). LP was used to solve a many kinds of problem. It could solve inventory management, labor scheduling, cash flow management, blending of product, and routing of delivery vehicles. LP could be model in Excel. Excel used solver add-in to create the LP model to find optimal solution. Albright & Winston (2006, p.74) said that Simplex Method was the application use linear programming to solve the problem and find the optimization.

A product Mix Problem. Furniture company manufacturers had got four models of the desks. There were three states of construction. The number of man hours required as of labor and the number of available hours in each states. Assume that raw material was unlimited. So find the optimal the production mix of each four desks to

find the maximum profit. This was an example of linear programming problem (Dantzig, 1963).

Kim (1971) adapted the mathematic model of linear equation systems. He introduced that "A given set of linear equations might have a unique, many, or no solution". The normal and basic linear equation could be shown like a set below.

$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n = 0$

$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n = 0$

.

.

.

$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n = 0$

This could be express as

$$\sum_{j=1}^{n} XjAj = 0$$

Where

$$Aj = \begin{pmatrix} a_{1j} \\ a_{2j} \\ \ldots \\ a_{mj} \end{pmatrix}$$

$x_1, x_2, \ldots, x_n$ are scalars and $A_1, A_2, \ldots, A_n$, they are vectors.

Source : Kim (1971)

A linear function included three properties. They were additivity, proportional and divisibility. The formulation would be like simplex algorithm, Stephen & Kenneth (2009).

For example of linear programming Stephen & Kenneth (2009) gave to example of the simply linear function formulation could be write in term C, D, T with maximum profit objective while selling each products.

$$\text{Profit} = 15C + 24D + 18T$$

$$\text{Constraint} : C \leq 360, D \leq 300, T \leq 100$$

Where : C = Chair, D = Desk, T = Table

The example above was given by chair, desk and table constants. The objective of the linear equation of profit was to find the maximum profit with selling combination of char, desk and table represent in term of linear equation.

The advantage of linear programming was simplex algorithm Albright & Winston (2007) said that it was not complicated and easy to formulate the function because the parameter could be in term of objective function coefficients, not appear like exponential function. However, Mangasarian (1964) linear programming had its own flaw. Some problem needed non linear to combine the equation to make it more accuracy. Mangasarian (1964) also introduced the linear and non linear patterns separation to represent the problem of two disjoint sets of patterns. It needed non linear programming to cover with. The result showed that even used the separation, it had to use non linear programming.

Other example of previous practical usage of linear programming was BASF Company. BASF North America packaging good company had been developed the optimization for their distribution goods. They used linear-programming model in order to improve the distribution system by trade-off between customer service and cost. The result of the new model helped them to improve the customer service and 10 percent reduction in annual cost (Salva, Vince, & Donald, 2001).

Data Collection by BASF used historical data on the product demand and costs from variety of source and made in consistency. With aggregate data collection method, BASF divided 25,000 SKUs to 382 business product category. The demand categorized by geographical regions. They grouped by postal zip code. The cost included with type of transport cost, type of truckload cost, unused space truckload cost. They generated the table of truckload cost. This table showed the relationship of cost per mile per full truck load, unused truckload space cost, distance between each aggregated postal zip code.

The delivery time was also an important factor for transportation. BASF model also used mileage tables available to be one of the constraints in their linear model. The table data had got volume delivery, service level, distance and time usage. Mileage would be applied in the optimize model.

2.2.2 Goal Programming

Charnes & Cooper (1963) proposed the goal programming to create the mathematic formula to solve the multi objective as close as possible. Goal Programming was used for solution of the multiple criteria problem. It could be interactive strategy for optimization multiple objective, said James (1972). Goal Programming was the tool when the decision maker faced the situation that there were more than one objectives while using the limited given resource (Multi Objectives). Moreover, the situation that was impossible to meet all objective in the same time. Albright & Winston (2007) gave the concept of goal programming was the way how to prioritize the objective to find the good decision. Here is the example of goal programming.

Table 2.1 Exposure for advertising in Television program

Advertisement	High income men	High income women	Low income people	Cost
Sports Show	7	4	8	$120,000
Game Show	3	5	6	$40,000
News	6	5	3	$50,000
Sitcom	4	5	7	$40,000
Drama	6	8	6	$60,000
Soap	3	4	5	$40,000

There were different exposures would receive from doing an advertisement on any particular program. The goal programming would find the optimization to reach the maximum audiences on high income men, high income women, and low income people within the advertising budget. The goal was to maximum number of all three groups of people. It was not possible the maximum in the same time with the limited budget. So they must prioritize these goals.

2.2.3 Integer Programming

Land and Doig (1960) had raised the common linear programming problem with integral optimization problems called "Integer Programming". The mathematical model which was involved all variables as integer value and discrete. Moreover, the constraints also considered as integral values. Balinski (1965) raised the common case linear programming using integer values were transportation problem, network flow problems. In transportation problem, "demands" and "supplies" consider the integer values. The new satisfaction must meet the integer property and also was limited with finite numbers. In addition, in network flow problems normally used only integral number for calculating the linear formula and its constraints. The example of integer programming would be shown on the next one, multiple integer programming

Nagraj, Barry & Ralph (2007) gave the example of the problem regards to Linear Programming model with the multi-objective. This could be solved by goal programming. Also another weak point of Linear Programming model was the limited

of decision variables and fixed variable. Nagaraj, Barry & Ralph (2007) said the weakness could be solved by Multiple Integer Programming (MIP). For example, the objective of the Linear Programming model was minimizing cost. If X was a number of toasts to make and each toast costs $10. So the total cost making toasts was $10X. This X could be called variable cost. However, in some situation, there were fixed cost unless you do not decide to make any toast. The total cost was going to be zero. So the problems which incurred fixed cost and variable cost, it needed multiple integer programming model to formulate and solve the problem.

The study case about Hardgrave Machine wanted to contribute new factory in order to expand its location covering in transportation to minimize the transportation cost. Hardgrave had raised two locations in their alternatives. They were Seattle and Birmingham. This problem needed MIP model to generate the result. The main constraint for the decision was

$$Ys + Yb = 1$$

Given : Ys is a decision to contribute new factory at Seattle.

Yb is a decision to contribute new factory at Birmingham.

Ys and Yb could be only 1 or 0. This result of decision would give the different of fixed cost.

The disadvantage of MIP model was, it was integer model. It had limited on the number. It also considered only one objective.

Yavuz, Sukran & Peter (2010) had developed the decision support framework for global manufacturer of specialty chemicals. The model considered the study of uncertainty of cost, lead time, and impact of demand and supply. The approach of the research was to combine the optimization and simulation in order to find the outcome while in the uncertainty. They tried to optimize cost and lead time of supply chain while there were uncertainty demand and supply which was using in simulation. It impacted the company performance. On the result showed that uncertainty demand had huge negative to supply chain performance forecast. They adapted mixed integer programming (MIP) model for exchange rate fluctuation, changing in demand, supplier reliability, and lead time on the total cost. The result showed that there was increase supply chain performance by 10%. This drawback of the model was it created too simplified supply chain structure. The test result might

not be good to real-life environment. The decision maker might feel not enough flexible support data.

2.2.4 Network Model

Network Theory could use linear programming to represent the network structure. Network was a combination of the developed structure, stated by Dantzig (1963). Network could be used in variety of representing any connections. For example, transportation, shipment of goods from source to destination, electrical system and computer communication. It showed the flow of any point, call node, to any point. Kim (1971) said, it was very popular representative of transportation problem and flow control.

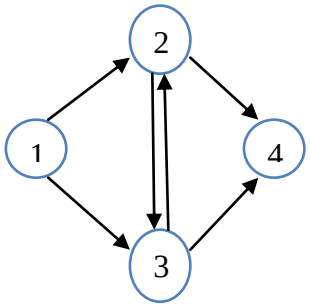


Figure 2.2 A Simplex Directed Network

Source: Dantzig (1963)

The figure above could be called graph. Dantzig (1963) discussed the graph was a collection of nodes and paired of node in each circles. The set of pair nodes represents the direction could be called the direction as a source and destination.

Stephen & Kenneth (2009) presented that network model was of the common model to help solve the supply chain problem. The network model would show the diagram like geographical location. It could present the path of shipment of goods from suppliers to customers in term of set of locations. It could be represented the place as node. The network model could be applied with supply chain structure in the new form of transportation model. Normally, the supply chain included suppliers, customers, and warehouses to be nodes in transportation model. The network model could be use as with linear programming to optimize the problem such as shortest path routing.

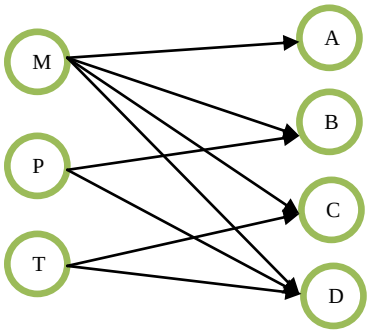


Figure 2.3 Network Model

Source: Albright (2007)

The Logistics center became a common strategic for distributor. The well design logistic center development considered about stock system monitors, controls of good movements in and out warehouse, organization, further delivery goods and final consumers. Albright & Winston (2007) the right strategy and decision would allow the company decrease the cost.

Olga (2010) researched the optimization for delivery goods used circular delivery route. The traditional supply chain was showed as the order of Producer, International Buyer, Wholesaler, Retailer and the last one was Consumer. Olga (2010) had a waste cost on transportation cost between each branch. There were several feasible routes for transportation. Olga tried to find the best transportation scenario that helped Olga to lowest their cost. Not only transportation cost but also they considered the value of goods. Olga presents the decision factor called "value of goods" by the formula below.

$$Vi = Ni \cdot Pi$$

Where:

Vi = Value of Goods;

Ni = Quantity of Goods;

Pi = Price of Goods.

With the formula, it could be value to goods that were in the stock and warehouse and positioning them all to ABC group chosen method. Group A had significant financial value with low quantities. Group C took huge stock position, but

low financial value. The rest were put in group B. ABC had become a popular method in many areas. This case showed that the logistic center had two trucks with 22 tons capacity each.

The result of their optimal task was to create two circular routes. Their base was Riga. Both two route scenarios started from Riga and came back to Riga again as final destination. Figure 2 showed the optimum route with 2 circular routes by Olga (2010).

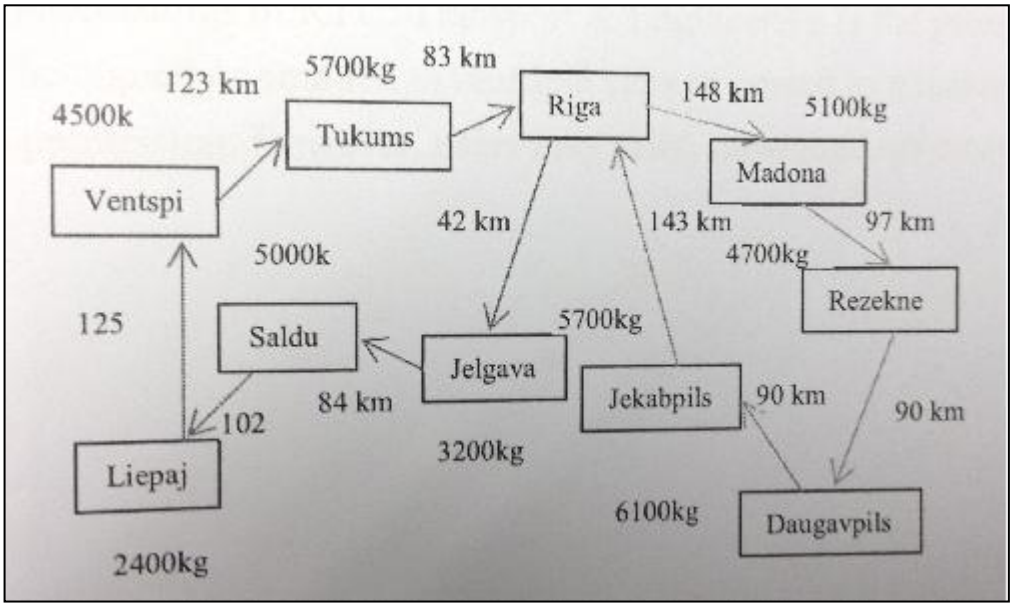


Figure 2.4 The Optimum 2 Circular Routes

Source: Olga (2010)

2.2.5 Optimization Software "CargoWiz"

Optimization method also could use the software to help for the optimization. Softtruck Co.,Ltd.. created the "CargoWiz", the software generates the optimizing truckload 3D layout. The software could fit with Manufacturer, Customer Service and Sales, Logistics Provider, Importer, Exporter, and crating and packing services. This software uses proprietary optimization method. The algorithm was procedural steps combined with trials in order to find the tight fit. The initial of the software needed to input all product carton dimensions, show in figure 2.5 and the container dimensions, show in figure 2.6.

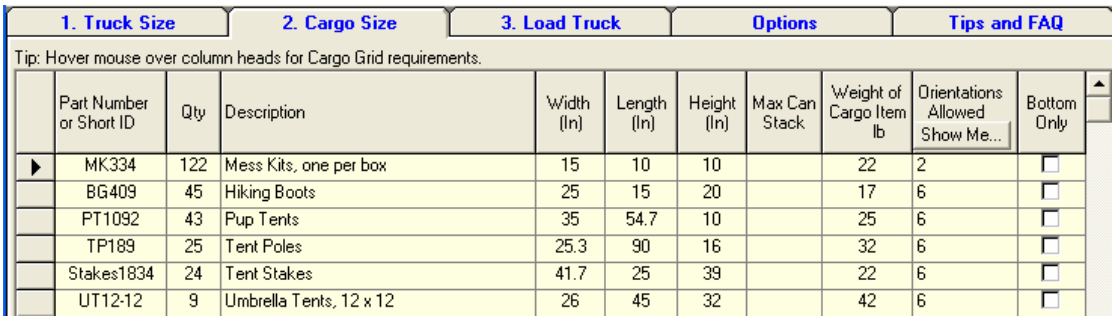


Figure 2.5 Product Dimension in CargoWiz

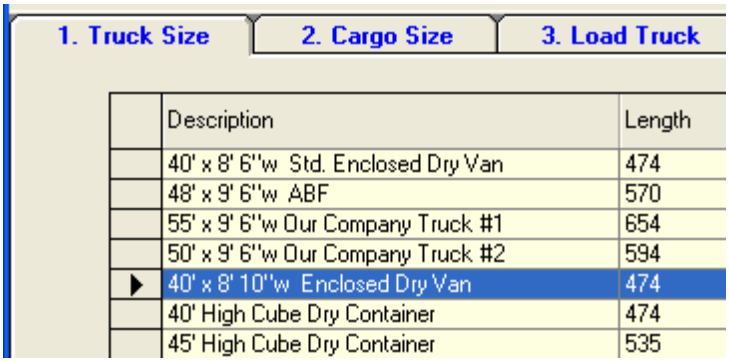


Figure 2.6 Container Dimension in CargoWiz

After the first initial, it needed to input the amount of product items that wanted to load into container. Then “CargoWiz” would generate the optimal 3D container layout for loading, show in figure 2.7.

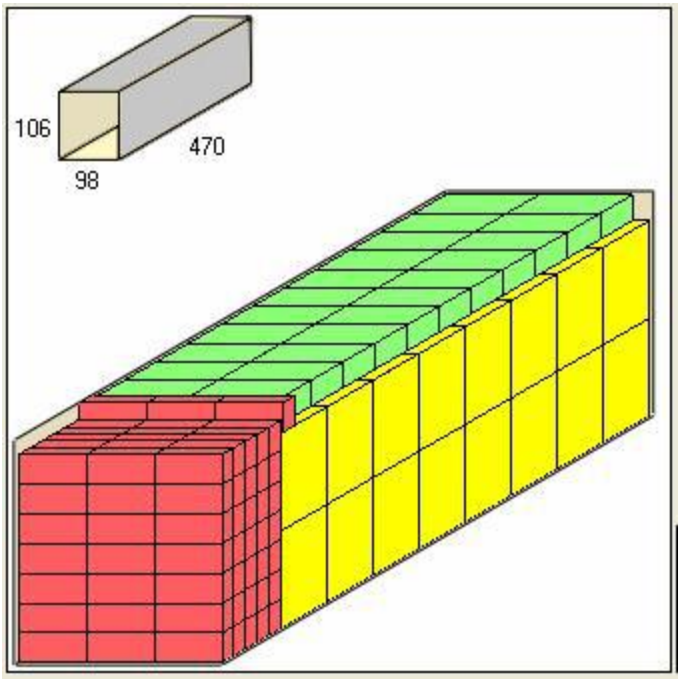


Figure 2.7 3D Container layout for loading from CargoWiz

2.3 Transportation Optimization Example

2.3.1 Transportation Problem

Dantzig (1963) discussed about the general case for transportation problem that normally in linear programming, they considered transportation problem as a network-flow problem. Transportation problem determined the minimum cost for network flow capacity. That could be implied as the objective of linear programming in network model. The classical transportation problem would consist of four rules.

1. The shipment were originate and available at source.
2. The shipment were allocated and delivered to destination while the amount of quantities received must meet the requirement.
3. The total demands must be equal to the total given supplies.
4. The cost of each shipment calculated from the source to the destination. The total cost must be feasible with the objective of linear function.

Dantzig (1963) gave the example of linear programming in transportation could be stated in the mathematical formula. The statement below showed the assumption of the transportation with total demand must be equaled to the total supply.

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j = T$$

Where:

$a_i \geq 0$, $b_j \geq 0$

a_i number of goods to be disposed of the each origins

b_j number of goods to be received at each destinations.

m number of origins

n number of destinations

T total amount of shipment goods.

The cost c_{ij} was represented the shipment cost per unit quantity from origins i to destinations j. The x_{ij} was represented the each quantity of goods from origins i to destinations j. The objective of this transportation was to minimize the cost of shipments. It could be represented in mathematical model below.

Minimize $\sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}x_{ij} = z$

Subject to $\sum_{j=1}^{n} x_{ij} = a_i$, $i = 1,2,\ldots,m$

$\sum_{i=1}^{m} x_{ij} = b_j$, $j = 1,2,\ldots,n$

$x_{ij} \geq 0$, $i = 1,2,\ldots,m$, $j = 1,2,\ldots,n$.

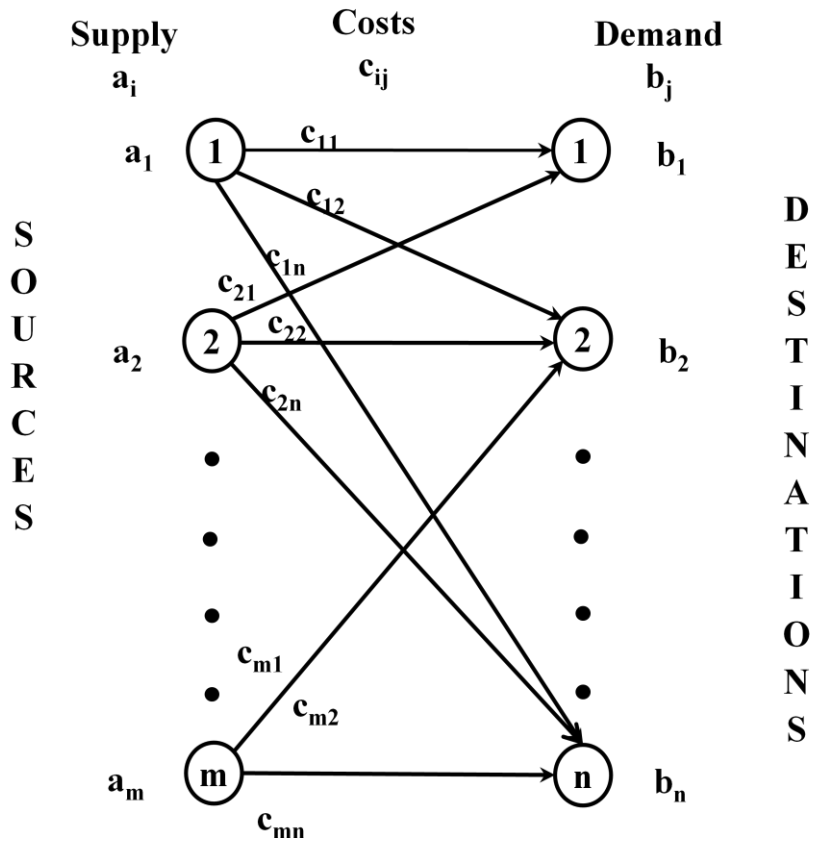


Figure 2.8 Network Representation of the Transportation Problem

Source: Dantzig (1963)

Kim (1971) showed the simple example of transportation and transshipment problem with linear programming. It assumed that there were two manufacturing plants of trucks engine. The engines must deliver to assembly plants which the company had three assembly plants. The daily engine manufacturing output must be equal the requirement of the assembly plants. The company wanted to find the minimum delivery cost of the trucks engines that must be sent from manufacturing plants to assembly plants. The table below showed the company truck engine data.

Table 2.2 Truck engines data

	Outputs		Requirements
Manufacturing Plant 1	500	Assembly plants 1	300
Manufacturing Plant 1	500	Assembly plants 2	300
Total	**1000**	Assembly plants 3	400
		Total	**1000**

Source : Kim (1971)

The transportation problem of this example wanted to minimize the total shipment cost for truck engines from Manufacturing Plant to Assembly plants. Each transportation path also had different shipment cost.

2.3.2 Truckload Optimization

Birlin, Martinez & Ronconi (2005) said that to minimize unused space in a particular container by rearrange the products in container, more product could be send within limited space. So it helped reducing delivery cost. The optimization model used three dimension parameters – width, height and length.

The new method, “Sentinels”, they were sets of items which were packed overlapped. One or more items of products were located inside or inner of the unused space of the other products. This method helped to optimize the packing technique.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Approach

This research objective wanted to create the optimization transportation framework for Manufacturer Company in order to use it to get a better performance in transportation system. The framework was developed from Albright & Winston (2007) seven-steps framework process. This research would test the developed framework with Manufacturer Company as a case study. This research would demonstrate the usage of developed framework for optimization transportation. In addition, it would show the company case study's optimization result with this developed framework.

3.2 Overall Methodology

The research purpose was to create the framework. Before creating the framework, the reviews of related literatures were important. The framework of this research was developed from Albright & Winston (2007) seven-steps framework process. The research would fit in the solution and knowledge from the past literature into each step of the framework. Altogether, this research could generate the complete optimization transportation framework.

After getting the complete optimization transportation framework, then this research tested the framework with a case study. The research would collect data from a manufacturing company as a case study to test the framework. Then, it needed to validate the framework and correct it to get the final framework for the research.

3.3 Related Literature

There are several literature reviews in chapter 2 which are involved in this research. The researchers are discussing about Transportation Concept, Optimization Method, Linear Programming, Goal Programming, Multiple Integer Programming,

Network Model, Truckload optimization, Modeling Framework and Delivery-time competition. The Network Model can be shown as transportation paths with the distances. Linear Programming, Goal Programming and Multiple Integer Programming can all be optimizing method in this research. The model may be heuristic model. In addition, all of the three optimization methods can be used as a guideline the key performance index. It helps to find the targeted KPI in the mathematical model.

3.4 Framework Development

From the optimized decision model, Albright & Winston (2007) recommend the seven processes. The seven-steps are define problem, data collection, model development, model verification, optimization and decision making, model communication to management and model implementation. This research will create framework adapted by the seven steps from Albright & Winston (2007)'s optimized decision model.

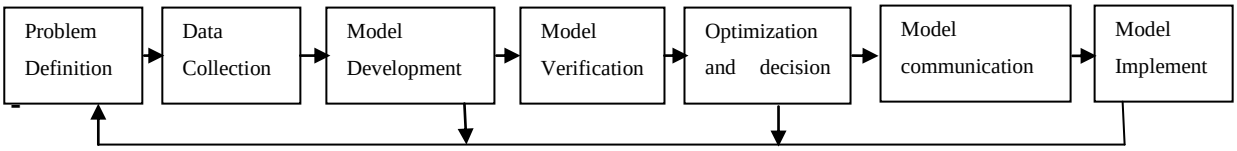


Figure 3.1 Flowchart for the Seven-Step process

Source: Management Science Modeling, Albright & Winston (2007)

In addition, the framework would focus deeply in optimization model development. Here is the draft of new model development of optimization transportation framework.

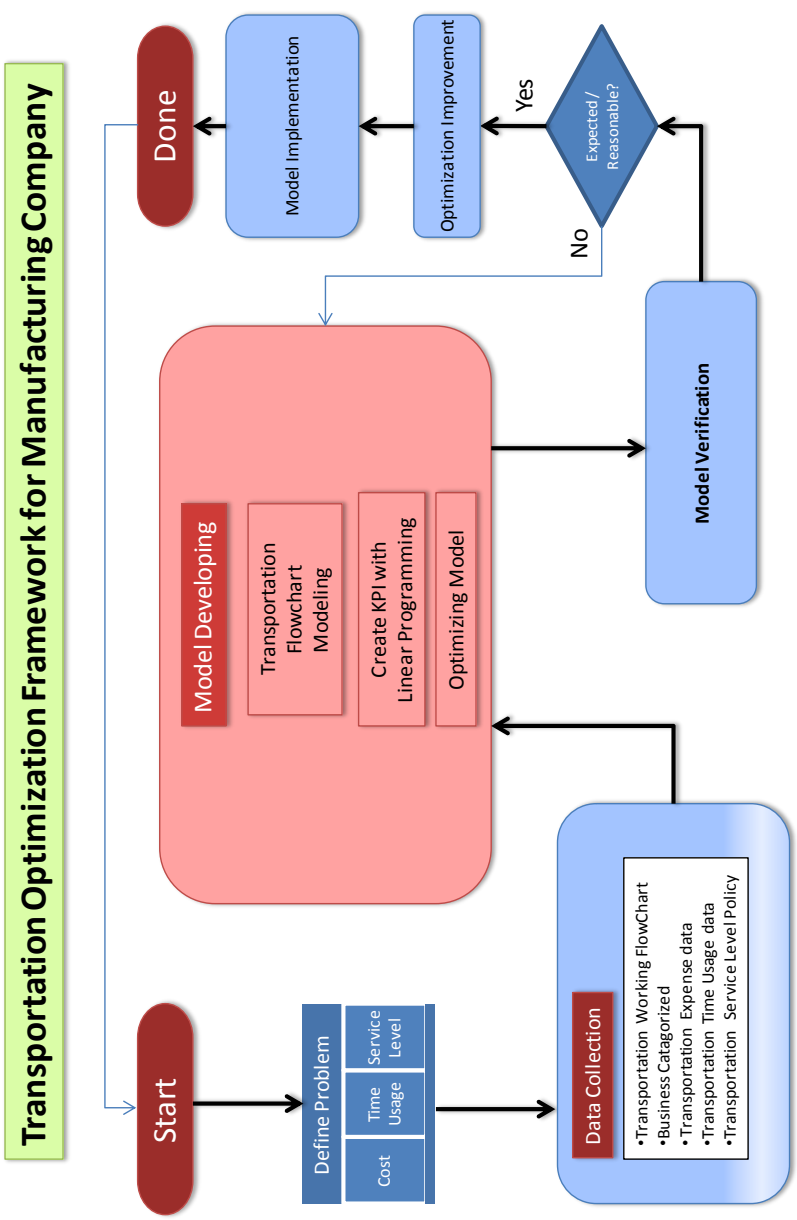


Figure 3.2 Optimization Framework for Transportation in Manufacturer Company

The optimization framework apapted from Albright & Winston (2007).

In figure 3.2, Souder (1972) said that the suitable criteria for project selection model are ease of use, realism, and flexibility. The model should be able to use easily. The management team can apply it easily with their company data. The framework also needs to be flexible for other related company as well.

There is an omission of Model Communicate to Management step from the seven-step. It needs to communicate along the way as Albright & Winston (2007) suggested. That is the adaptation of this framework in this research. This should instead be done in the beginning to the end of the project.

3.5 Framework Validity Check

Saul (1982) recommended about the model and framework validity. The flow of framework must be logical and sound good. The data should be real for testing. This would make the framework valid while developing it.

3.6 Case Study

The case study has to be the Manufacturer Company who has their own delivery management team or department. The researcher finds the volunteer company to test the framework. The company must give real and appropriate data. This will help the realism of framework. Otherwise, the adapted framework might not be functional and useful. The framework would require all the data that is involved with transportation. For example, labor cost, customer distance, truck availability, driver availability, customer service level, some limitation resource of company, company constraints and goals for delivery, etc. Moreover, all data of delivery department must be collected. The appropriate set of data can pinpoint the problem. Without sufficient data, the optimization might give low potential of improvement and generate wrong KPIs result.

3.7 Test Framework with case study

First of all, the case study has to be understood fully and then prepare the assumption for the case. After that, the research will apply this case study into the

optimization transportation framework. Then, follow the six steps in framework. There should be the result of improvement that generate by this framework.

3.8 Check the result

After getting the result from the framework, the analyzer needs to check the result whether it is practical in real world or not with validating assessment (Gass, 1982). Check and verify if the result is satisfied or not with the case study company delivery management team.

3.9 Make necessary change to framework

In the testing of case study, if there is any issue occurring while it is running on this framework, the analyzer should go back to adjust some part in the framework to make it more perfect.

3.10 Consolidate framework with framework instruction

Finally, after correcting the framework and all validation of framework, analyzer needs to add or combine the adjusting part of framework to the framework instruction. In this stage, it will create the final framework. Finally, the result of the research optimization transportation framework is reported.

CHAPTER IV
CASE STUDY

This chapter showed and demonstrated the adapted framework of optimization transportation. It demonstrated each step in the framework with case study. The case study was used to validate the usable of research framework.

4.1 Case Study Overview

SMP Wireplast Company Limited was used as our case study. This company produces household plastic products. The company job was to produce the plastic goods and deliver them to their customers which considered as a wholesaler. There were customers who are not located in Bangkok. The company used Courier Company which has got their warehouse in Bangkok the center of distribution. Goods always packed in the square carton. Different product has got different carton dimension and size. There were several international customers. The goods must be sent to Bangkok Seaport by booking. The delivery method always used truck as carrier. Currently delivery team needed to analyze the product order and created the truckload and route scenario daily for delivery plan within the constraints and resource limitation daily. There were usually conflictions for the best deliver plan. Normally, the company always considered deliver plan with the lowest deliver cost. Currently, there was no use of tool, guideline or framework to help the planning go on the same direction and generated the lowest cost plan. It was very competitive in the household plastic product market. Many firms could produce the similar plastic product to competing with pricing and delivery service.

The optimization process from the developed framework to test with SMP Wireplast Co.,Ltd.. demonstrated step by step below.

4.2 Define Problem

According to the framework, there were three types of problems in delivery service. They were cost, time usage and service level. Since the company was in the competitive market, especially perfect competition market.

The most concentration on optimization always pointed at cost. The company wanted to reduce the deliver cost as much as they can. So they could fight and survived in the market. There were labor cost and fuel cost. Both of them were the most important factor on Delivery Expense.

Time usage was also one of the indirect costs. Company claimed that they allocate timing not efficiency which they believed that it could be better. Company pinpointed the wasted time on some parts such as truck loading time usage in their work flow.

The last problem of delivery was service level. The company got cancellation of product order because of delay deliver products. In competitive market, any supplier and deliver their product fast could enjoy the moment of sales, especially, the promised delivery date. There were occasionally cancellations on undelivered promised product. The customer switched to other suppliers. It was because of wrong planning strategy. The goods could not send out by plan. The risk of purchase order cancellation was the consequence.

4.3 Data Collection

The researcher had gathered all involved information and data from SMP Wireplast Co.,Ltd.. as a case study. Then the researcher drew the delivery planning work flow of company in a chart below. The work flow demonstrated in each working step by responsible person.

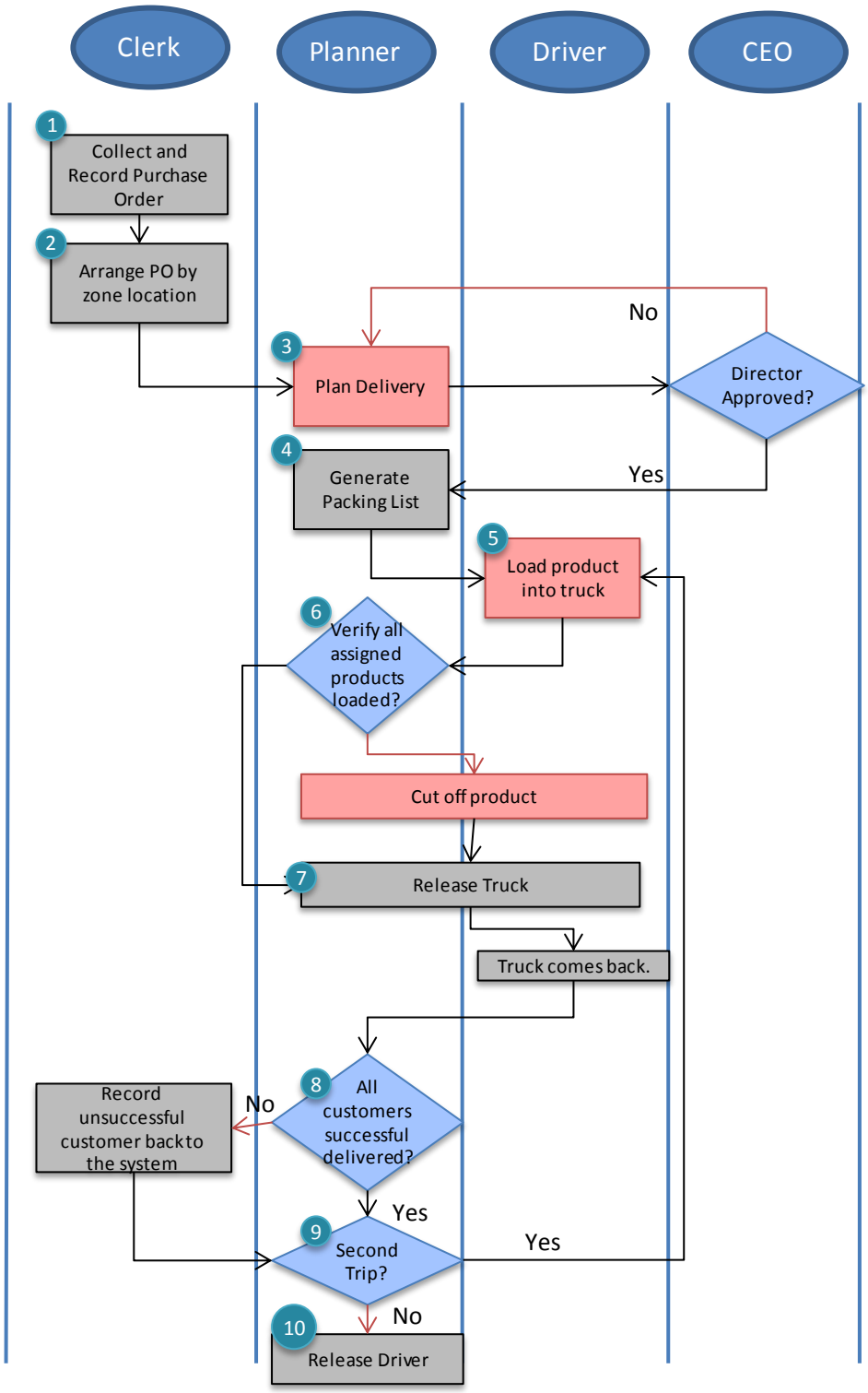


Figure 4.1 Case Study - Current Delivery Planning Work Flow

Current Delivery Planning Work Flow Step explanation

1. Collect and Record Purchase order

a. Receive the purchase orders from the phone call and from sale persons.

b. Record the request purchase order in the computer system.

c. Take out all purchase orders. Consider only customer who's their finish products ready to deliver.

d. The responsible person is clerk.

2. Arrange the purchase order by zone location.

a. Choose only ready to go customer who's their product already produced.

b. Arrange them by customer location zoning. Location zones were divided by geographical map. The location zoning were divided by the main street and highway road. In addition, normally customers were located together like cluster market. There were many customers in each location cluster. These were list of current zone location division.

1) Mid-Town – Sum Peng and BoBae.

2) South West – Bangbon 5, Rama II and Mahachai.

3) East – Bangna Trad road.

4) North – Rangsit, Talad Thai market, Nonthaburi.

5) Big Company – These were customers who always order full truckload. The truck had to dedicate for them – BigC and Ayuttaya Wholesaler.

6) Bangkok Seaport – All the customer who wanted us to deliver to Bangkok Seaport.

7) Courier Company—Puttamonthon Sai 2 & 3 & 4

c. The physical 7 zones locations showed in the map in appendix.

d. This step was done by clerk.

3. Plan the delivery.

a. There were four drivers with one six wheels truck and four of four wheels truck. Four wheels truck needed another male labor to go with. All four wheel trucks had got similar capacity. The six wheels always needed other 2 male labors with plenty of space for loading product. The truck capacity showed in the truck dimension table.

b. All company products were packed into square carton dimension. There were several carton sizes. The carton sizes showed on the product dimension table.

c. The plan had to determine the customer location, time usage and truck loading capacity. The sending location must be on the same zone. After deliver the product the truck must come back to the company before proceed the new task.

d. Time usage approximation must be determined for the driver to come back to company within the working time, 5 pm. In addition, the planner could allow the over time working for each truck, if it was necessary.

e. The plan had to come up with number of cartons of each product to load in each truck. This was going to write down in paper and gave this to the driver on the next morning.

f. Normally, truck load plan used approximate truck space usage by calculating the total product capacity space usage must be less than 80% of truck capacity. 80% truck space threshold had risen up from the past experience overloading truck. With 80% approximation considered it as full truck capacity, there had never shown up the overloading truck.

g. Each driver had their responsible 4 wheels truck. All of them could drive 6 wheels truck as well.

h. Look at the chart for planning flowchart strategic.

1) Zone division by 7 zone location. This was the first step of delivery plan strategic which was used every day. The total capacity requirement each zone calculated by hand and calculator of clerk. There was no computer software involved in this step.

2) Allocate the six wheels truck first, if there was any zone capacity requirement exceeds 130% of 4 wheels truck capacity. Six wheels truck usually delivered product to North zone and East zone. If North zone and East zone required six wheels truck. The first priority was North zone. East zone needed to wait for the next delivery day. There was no assignment to 4 wheels truck and cut off some product.

3) Assign driver for Mid-Town zone by rotating. Normally, company needed to delivery product to Mid-Town zone every day. Mid-Town zone was considered as more difficult delivery zone due to the traffic in Bangkok metropolitan area. There was no fix driver to Mid-Town zone for fair assignment.

4) Assign daily priority customer with his zone. That mean, that customers in that particular zone were going to be delivered. The company could ask some big customer to send extra product more than they had pre-ordered in order to fulfill the priority truck.

5) Assign the rest top most capacity requirement zone to the rest drivers. There was no fix driver for each zone. It randomly allocates. The unallocated pended for the next planning strategic.

6) Calculated truck load each truck by trying to the most fit truck load. The planner used 80% of truck capacity consider as full truck load. If there was exceed capacity, some customers needed to be cut off by the planner. The planner thought only the best fit and most fit into truck in order to lowest the unused space. These were all done by calculator. There was no software involved to help planning the truck load or any truck load layout. From the experience of planner said that 80% of truck capacity would make sure 100% of no cut off customer. In addition, some priority customers would not been cut off if it reached exceed space. The planner would choose other customers to cut off in order to fully fit the truck.

4. Generate Packing List

a. After get approval of CEO, the planner wrote down the paper of packing list and gave to each driver.

b. The paper included the amount of each product to load and customer list.

5. Load the products into truck next working morning.

a. All drivers received the delivery assignment in writing.

b. They went to take all products from the inventory that had assigned in the job paper on the back of the truck on the floor step before load into truck.

c. Count total amount of product on the back of the truck in order to verify the total amount of product before loading into truck is similar to the assigned paper.

d. If the amount of product on the back of the truck was not equal to the assigned paper, then the driver needed to carry out the missing product or carried back to exceed product from the inventory.

e. The drivers started to design their load layout in to the truck with their arranging style and layout without any layout plan paper guideline from executive. All the products could be done loading was all up to the driver's loading skill.

f. There were few problem of overload truck. If it happens, that particular customer had to be all taken down all their product orders. It was no good, if the company promised delivery date has been postponed. This will create bad reputation and other consequence. For example, the next trip would need to be all revised again. The delivery planner had to redo the job.

g. 80% of full truck capacity was used for consider as full truck load. The driver must arrange in the good layout as well. The space could not be too loosed; otherwise it would not fit on 80% approximated.

h. This step was done by driver and labor.

6. Check all assigned product had been loaded.

a. If any products had not been loaded, the planner needed to cut off the unloaded product customer.

b. The unloaded customers purchase order would be recorded back the system again.

c. The service level of company could be impacted from cut off customer. Customer might switch to other supplier.

7. Release the truck. After finish loading, the planner would release the truck.

8. Verify if all customers have successful delivered.

a. After the truck had been send out and come back to the company, the planner needed to check and verified that all assigned customers successfully delivered.

b. Record the undelivered customers back to the system by clerk.

9. Loading the truck for second round.

a. Some customer zone or some huge orders might need more than one truck.

b. The second round could be done, when there were still the purchases orders which could be delivery in time for the working day or the planner thought for necessary for over time working for the driver.

c. If there was a second round, the driver had to go back to step 5 and continue the delivery job.

10. Release the driver. When the drivers finished their entire delivery daily job, they could relax by maintenance the truck and checked off by the clock out time.

The sub flow chart on step 3 and step 5 showed in figure 4.2 and figure 4.3 by order.

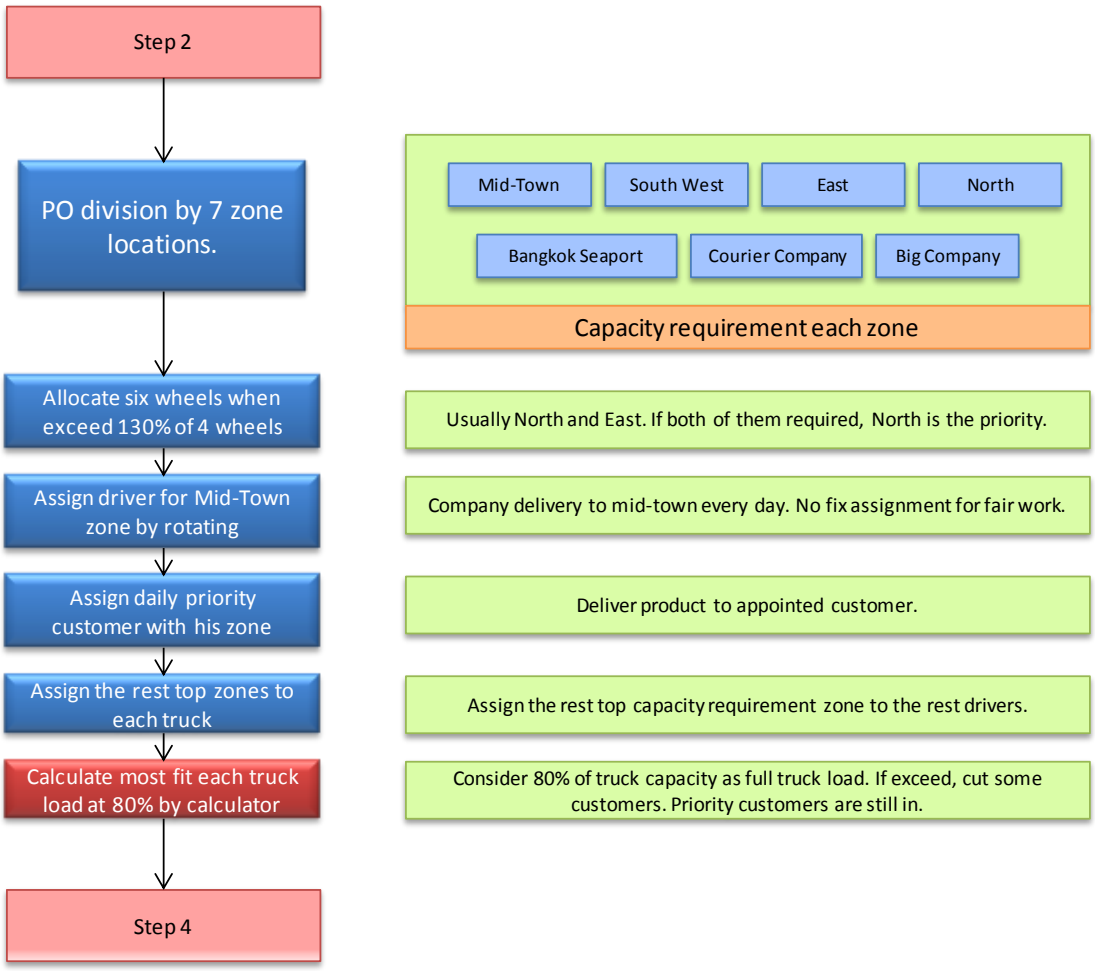


Figure 4.2 Current Delivery Plan Strategic Step 3 expand

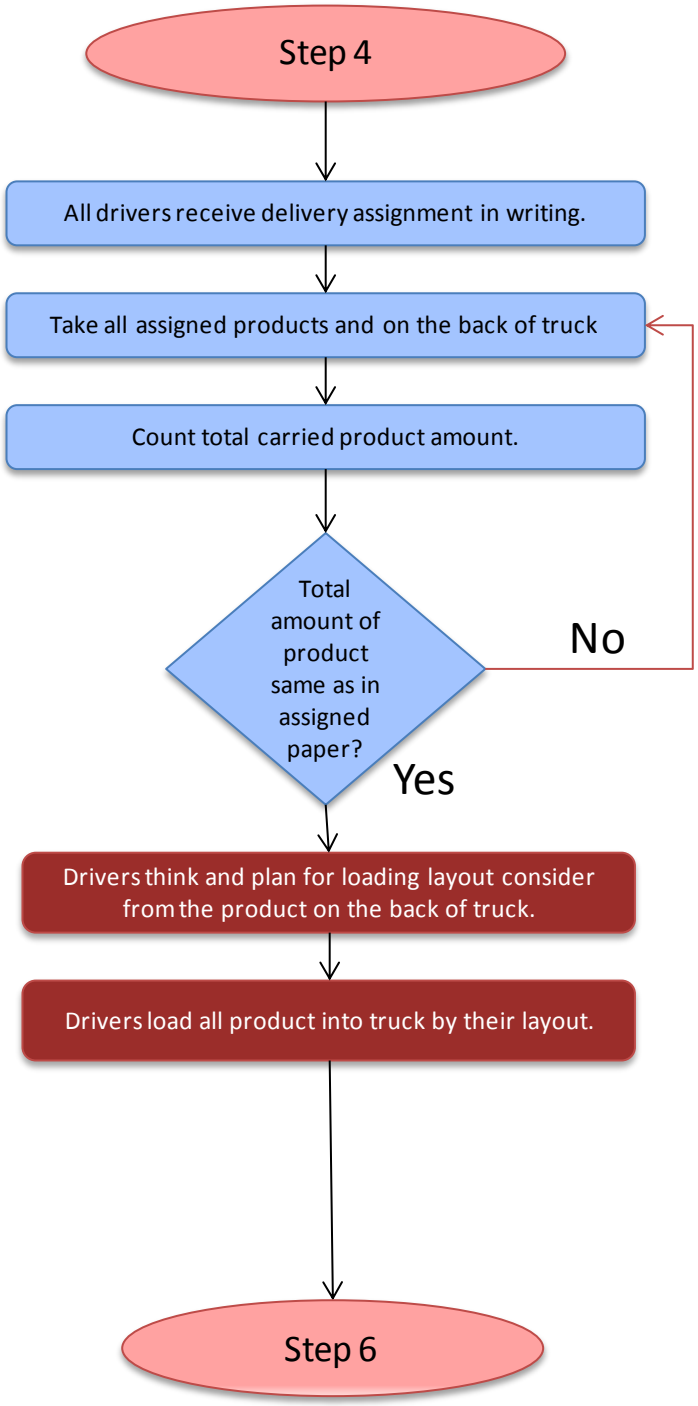


Figure 4.3 Current Truck Load Strategic Step 5 expand

There were four people involved in the delivery planning ten steps. They were clerk, planner, driver and CEO. Each step explained below.

In step 3, Plan delivery, the researcher curious the red box which defined as a problem. The company used 80% of truck capacity consider as a full truck

capacity. The 80% came up from the experience of the truck load problem. With 80% of planning calculation, it guaranteed the all amount of product could be loaded by the plan. It could help protecting the cut off problem and easier for driver to load all products a bit loose. So the research thought that the 20% of unused space of truck capacity is wasted space. This was a part of wasted on Delivery Expense. The several questions had come up that could it be optimized? How much it could improve?

In step 5, Truck Load Strategic, the research could see the wasted time on the truck load strategic defined in two red boxes. The driver retrieved amount of each product to deliver, however, there was no layout of truck load guideline from the planner. Currently, the driver thought by himself for layout planning. The driver tried to fit all products/ by himself. There were two events the research found when the researcher observed. The drivers did not write down on any layout plan from this head. He tried to fit in as lowest unused space as he could. When he found the big hole of unused space, he tried to rearrange them again in order to see the small hole of unused space. He wasted time on rearranging the products. The next step of Model Development is, define the KPI of the case.

4.4 Model Development

Regarding the data collection and the work flow chart, the research tried to pinpoint more specific the problems in the work flow. The research found that the problem could be optimized in the step 3 – Plan Delivery and step 5 –Truck Load strategic.

4.4.2 Define the KPI with linear programming

Regarding from the research framework, after gathering more data, it was time to develop the model. Firstly, the researcher created the key performance indicator of this case study with linear programming. The **KPI** of this case study was **Profit**. The performance of transportation of SMP Wireplast Co.,Ltd.. was related with company's profit. The profit function showed in linear formula below

Profit = Revenue – Cost – Expense

The objective of profit function was maximization. In order to maximize the KPI, profit, it needed to consider more on revenue and expense which were the related factor of profit. Transportation was considered as expense of the company.

That expense needed use it efficiency. Sale Loss due to mismanagement of transportation was considered as decrease revenue. Sale Loss needed to do minimization. Both of loss would consider as Performance Index (PI).

The first PI of this case study was the **Loss in Delivery Expense** due to the problem defined above. Reducing expense could increase the company profit. Here is the definition of the involved function to **Loss in Delivery Expense** (**LDE**) function.

Truck Unused Space function

$$\text{Unused Space } \textit{(truck)}\ (\%) = 1 - \frac{\text{Total Loaded Product Capacity (sq.cm.)}}{\text{Truck Capacity } (\textit{truck}) \text{ (sq.cm.)}}$$

Variables	Description
Total Loaded Product Capacity	This represents the total capacity of the products that have been loaded. It was not the capacity which comed from the planning calculation.
Truck Capacity	The capacity of the loaded truck which was measured by the real empty truck space.

Delivery Expense per round function

Delivery Expense per round *(truck type, Zone)* = [Zone distance (km) x Fuel Cost (*truck type*)] + [Labor Cost (*truck type*)]

Variables	Description
Delivery Expense per round (Baht)	It is the cost the company needed to use for any delivery trip.
Zone Distance (km)	The round trip distances for any trip each zone. This represent on the table was on the appendix.
Fuel Cost (Baht/km)	The fuel price per distance kilometer of any truck consumes. This represent on the table

	wais on the appendix.
Labor Cost (Baht/Day)	The driver and labor people who needed to go with any truck. This represented on the table was on the appendix.

Loss in Labor Cost (Baht)

Loss in Labor Cost *(truck type)* =

$$\frac{Extra\ Time\ if\ rearrange\ \ (mins) + Time\ Saving\ for\ layout\ \ guideline\ \ (mins)}{8hrs\ x\ 60mins}$$

x Labor Cost *(truck type)*

Variables	Description
Extra Time if rearrange (mins)	The extra time the driver needed more for rearranging when he found the big hole of unspaced space.
Time saving for layout guideline (mins)	The amount of saving time of the truck load usage when the driver got the layout guideline for truck load on his hand. It was the different of time usage between with and without layout guideline.
Labor Cost (Baht)	The driver and labor people who needed to go with any truck. This represents on the table was on the appendix.

Lost in Labor Cost was the wasted cost for the driver and labor had to do extra job. There were two of them. The first one was extra time if it needed to rearrange the product carton in the truck when the driver saw that the current arrangement was no good to go further. It needed to revise the loading layout. Second waste cost was the time saving for loading time. The driver did not need to plan and think slowly. He needed just follow the guideline paper for truck load layout. Company could use the time saving for all delivery labor to continue other job in the

same day for extra work. In addition, the time saving might help some truck can delivery two rounds on the same day. It coul save the over time working payment.

Linear function PI of this case study

(**LDE**) **Loss in Delivery Expense** (i) = $\sum_{i=1}^{n}$ { [$Unused\ Space\ (i)\ x\ Delivery\ Expense\ per\ round\ (i)$] } + { [Loss in Labor Cost (truck type)] }

Variables	Description
LDE (i)	The **Loss in Delivery Expense** (Baht/Day) was the KPI of this case study. The objective of this function was to minimize this PI. This PI would show the loss due to mismanagement of delivery daily.
i, n	i represents each round trip truck daily. Total round trip is n trucks per day.
Unused Space (i)	Derive from the unused space function above.
Delivery Expense per round (i)	Derive from the Delivery Expense per round function above.
Loss in Labor Cost (truck type)	Derive from the lost in labor cost function above.

Loss in Delivery Expense was the total of occurrence of lost due to the delivery each round trip per day. It was the performance index (PI) of lost due to the miss managerial of truck load. The researcher wanted to find the solution to improve (minimize value) this PI. Lower **Loss in Delivery Expense** was a better performance. In this case, the researcher used minimizing PI to be as a objective of linear function.

The second PI of this case was **Sale Loss from Cut Off**. The bad consequence from cut off strategy in current company transportation work flow was, there was a chance for the customer switch to other supplier, because SMP Wireplast was in perfect competition business. It made company loss the known sale because of the mismanagement of transportation. Sale Loss from Cut Off could be formulate with linear programming show below

Sale Loss from Cut Off = Probability Sale Loss from Cut Off x Average Sale Amount

The objective of this PI was minimization. From the formula, it could see that the only way to reduce the Sale Loss from Cut Off was only minimizing probability Sale Loss from Cut Off. It mean that the less Cut Off, the less chance to loss known sale.

4.4.3 Optimization

The researcher found out the solution to improve the case's KPI. The researcher believed that there should be a truck load layout guideline to optimize the truck load and help guideline the driver for time usage saving as well. It found the software "CargoWiz" which was developed by Softtruck. It was a tool for calculate the container and truck loading. The Softtruck developed its own algorithm in this software to generate the container load layout. The container load layout demonstrated in 3D simulation, see in Appendix F. Their regular customers were logistic company. CargoWiz cost $US747 per license. It was approximate 23,700 Baht. The researcher tested the trial version of CargoWiz. The product carton dimension and truck dimension which showed in the appendix were the initial input to this trial.

The optimization trial tested with this software used the exceed truck load purchase order of the company as the input data to simulate the truck load layout a hundred time in 4 wheels truck and 6 wheels truck. To use exceed truck load was to see whether the most optimization performance. CargoWiz showed the 3D layout of the loaded products and showed the amount of unloaded products.

The result of the trial 3D simulation truck load of the case study could improve the unused space of each truck. The improvement result showed in the table 4.1.

Table 4.1 The comparison of unused space

Truck Type	Current Unused space	Unused space with CargoWiz	Improvement
6 Wheels Truck	20%	8.89%	11.11%
4 Wheels Truck	20%	11.17%	8.83%

The unused space had improved 11.11% and 8.83% on 6 wheels truck and 4 wheels truck. The result of unused space that case considered as a wasted cost had improved.

4.5 Model Verification

The result of model developing generated the 3D truck load layout. The truck load layout already calculated as the most fit in the truck. The model verification solution was, the model's output, 3D truckload layout, was given to the driver for their truckload layout guideline. The result showed that all products could be fit it the truck. The layout and the unused space of real loaded truck were exactly same as the layout simulation. So the model's output and real observed are similar.

4.6 Optimization Improvement

This step would show the result of optimization improvement of this case after using "CargoWiz", see the table 4.2.

Table 4.2 Truckload Optimization Result

	Current Model			New Model		
Truck Type	Unused Space	Loss in Labor Cost (Baht)	Loss in Delivery Expense (Baht)	Unused Space	Loss in Labor Cost (Baht)	Loss in Delivery Expense (Baht)
6 Wheels Truck	20.00%	63.75	414.05	8.89%	0	155.71
4 Wheel Truck 1	20.00%	30.625	194.95	11.17%	0	91.77
4 Wheel Truck 2	20.00%	30.625	235.23	11.17%	0	114.27
4 Wheel Truck 3	20.00%	30.625	204.83	11.17%	0	97.29
Total (per day)			1,049.05			459.04

The additional benefit from using "CargoWiz" was, it could deduct the probability sale loss from cut off to zero, showed as table 4.3.

Table 4.3 Probability Sale Loss from Cut Off

	Current Model	New Model	PI Improvement
Probability sale loss from cut off	1 sale loss out of 7 cut off times (Probability 14%)	0 sales loss out of 0 cut off times (Probability 0%)	100%
Sale Loss from Cut Off	235,872 Baht / Year	0 Baht /Year	100%

Combining two optimization improvements of PIs, Loss in Delivery Expense and Sale Loss from Cut Off, they improved KPI, profit, increase 419,953.29 Baht per year.

The net profit margin also could be determined as KPI.

$$\text{Net Profit Margin (\%)} = \frac{Profit}{Revenue}$$

According to table 4.4, this analysis used data on year 2011 consider as the base year analysis. The increasing in net profit equaled to net profit margin 0.35%.

Table 4.4 KPI Benchmark Analysis -- Profit

Year 2011			New Model		
Revenue (Baht / Year)	Net Profit (Baht)	Net Profit Margin	Net Profit Increase (Baht)	Net Profit Margin Increase	KPI Improvement
118,110,648	7,581,433 Baht	6.42%	419,953.29	0.35%	5.45%

With the new model, KPI Profit improved 5.45% compare to year 2011 as the base year analysis.

Table 4.5 Break Even Analysis

New Model Budget	New Model Net Profit Return	Working Day per year (Year 2011)	Break Even Point
23,700 Baht/License	419,953.29 Baht/Year	295 Working day	16.65 Working Day

The table 4.5 showed the break even analysis. With the new model budget, this model mainly purchase on the software "CargoWiz". It cost company at 23,700 Baht per license. The new model could save the loss 419,953.29 Baht per year. So the investment on software should be returned in 16.65 working days

4.7 New Model Propose

The optimization could modify the current work flow framework to the new one which it believed improvement of KPI 5.45%, showed in figure 4.4. The new transportation workflow for the company has revised the step 3 – Plan Delivery, step 5, load product into truck, delete step 6, cut off product and deleted the working load on CEO on step "Director Approved". There was no need of CEO to recheck again on transportation plan. The software reduced this work load.

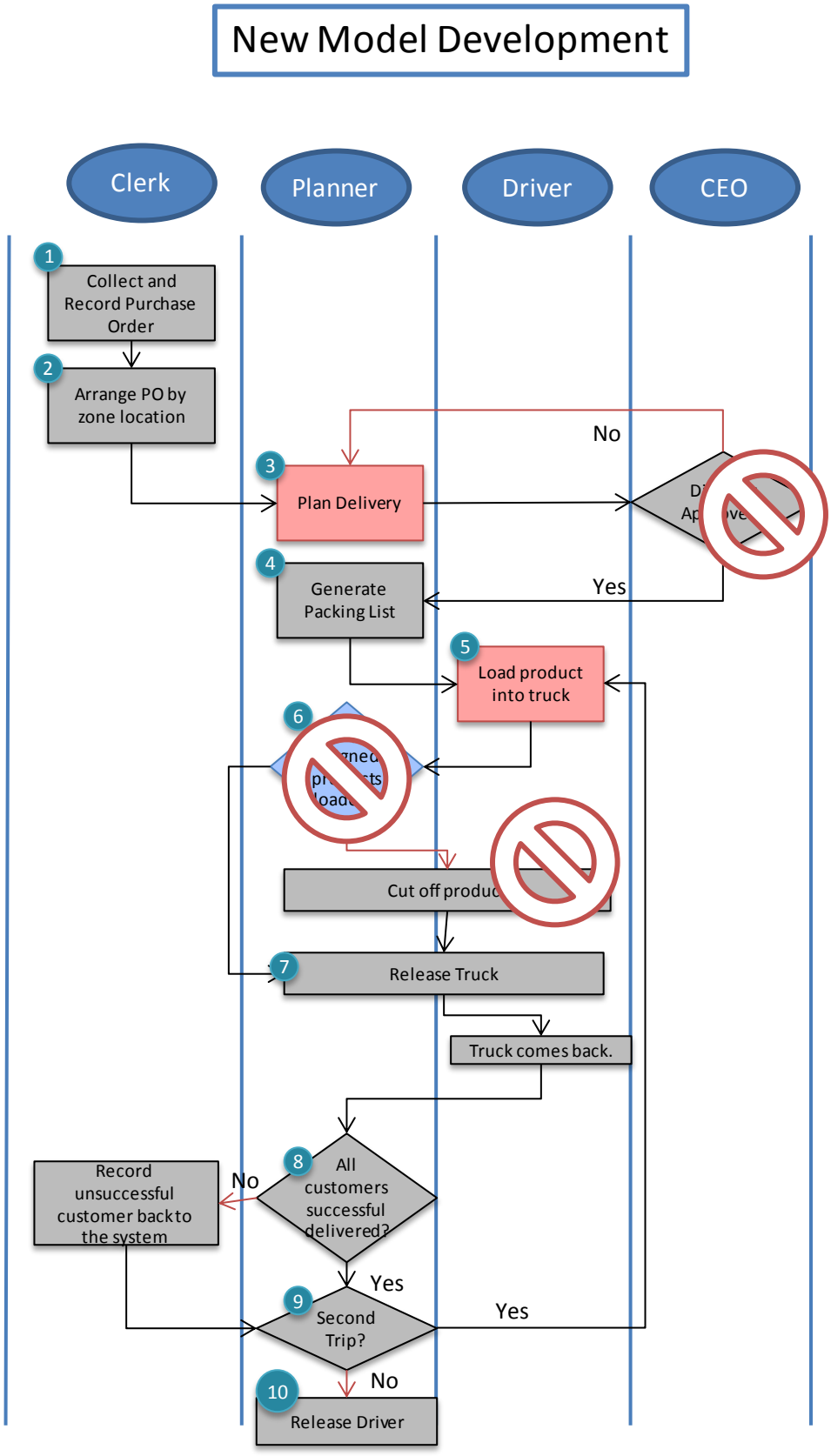


Figure 4.4 New Model Development

CHAPTER V
THE FINDINGS

This chapter would show the finding of the optimization framework for the case study after the discussion in chapter four.

5.1 Proposed new Transportation Work Flow for this case study

This research applied the optimization framework for transportation with case study, SMP Wireplast Co.,Ltd.. The discussion of optimization framework was shown in chapter four. The research used Profit as a KPI of this case study. The result proposed the new transportation model for the company in order to improve the KPI. The proposed model suggested adjusting some work flow in step 3 – Plan Delivery and step 5 – Load Product into Truck. The flow chart is shown in figure 5.1.

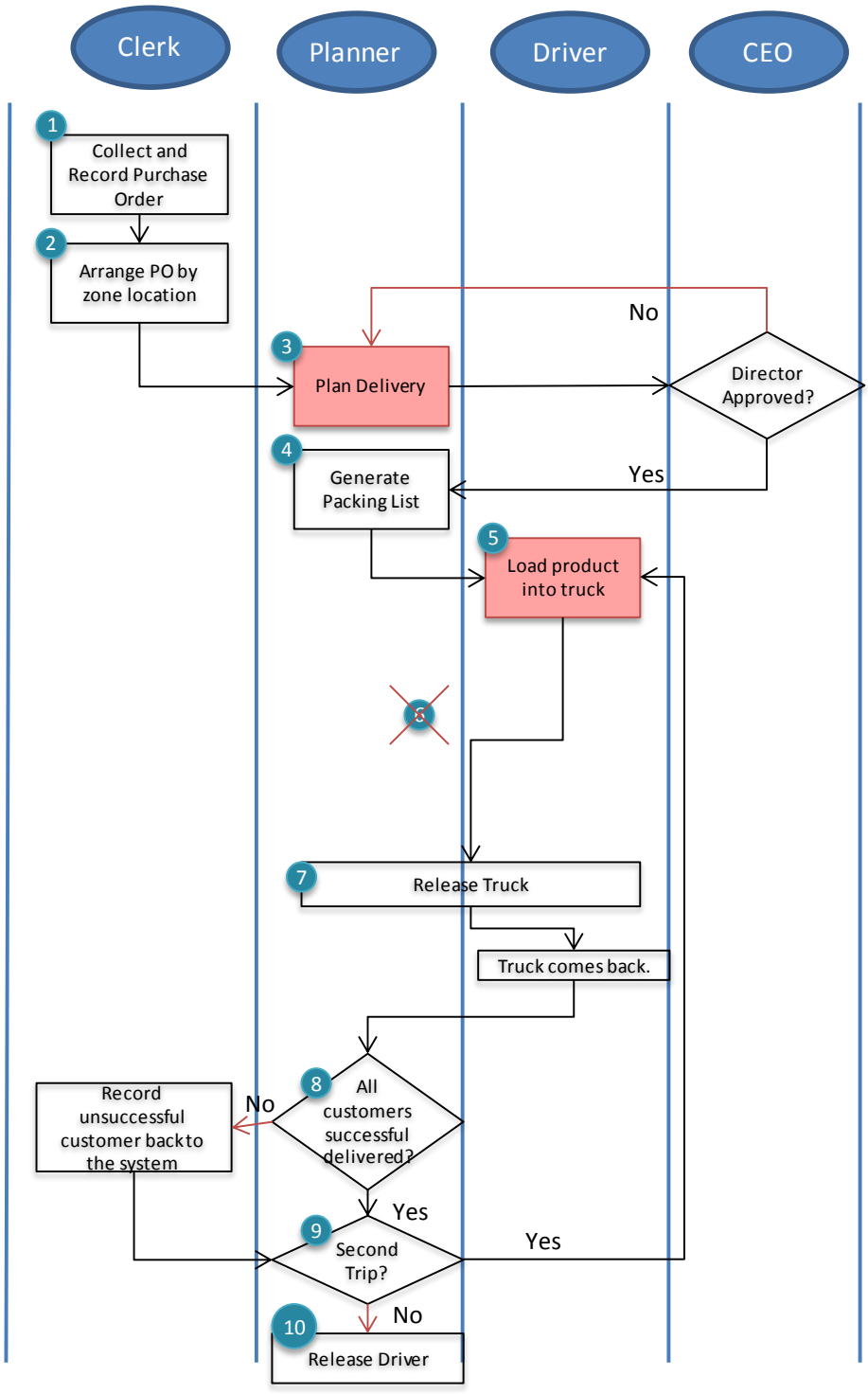


Figure 5.1 Proposed Transportation Workflow

In step 3, Delivery Plan, see figure 5.2, which was the final step in the work flow adjusted from "Calculate most fit each truck load at 80% by calculator" to "Optimize most fit each truck load by truck load software". With the optimization container truck load software called "CargoWiz", it improved the most fit on truck load from 80% to 88.83% and 91.11% of the 4 wheels truck and 6 wheels truck respectively. That mean, the unused space on truck load were 11.17% and 8.89% on 4 wheels truck and 6 wheels truck.

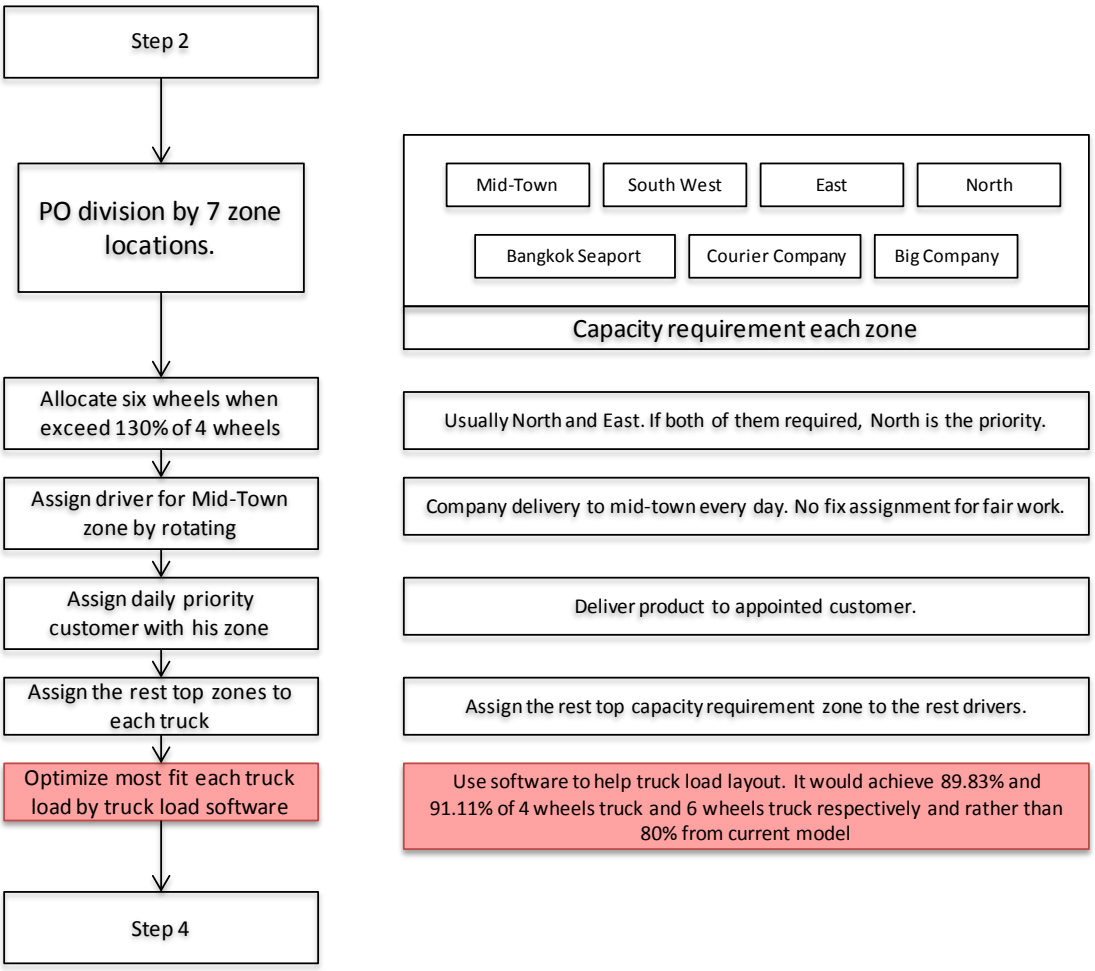


Figure 5.2 Proposed Adjustments in Step 3 – Delivery Plan

In step 5, Truck Load, see figure 5.3, which was the final step in work flow adjusted from “Drivers think and plan for loading layout consider from the product on the back of the truck” and “Drivers load all products into the truck by their layout” to “Drivers load all products into truck by recommended truck load layout from the software”. The drivers no longer have to consider the truck load layout by themselves.

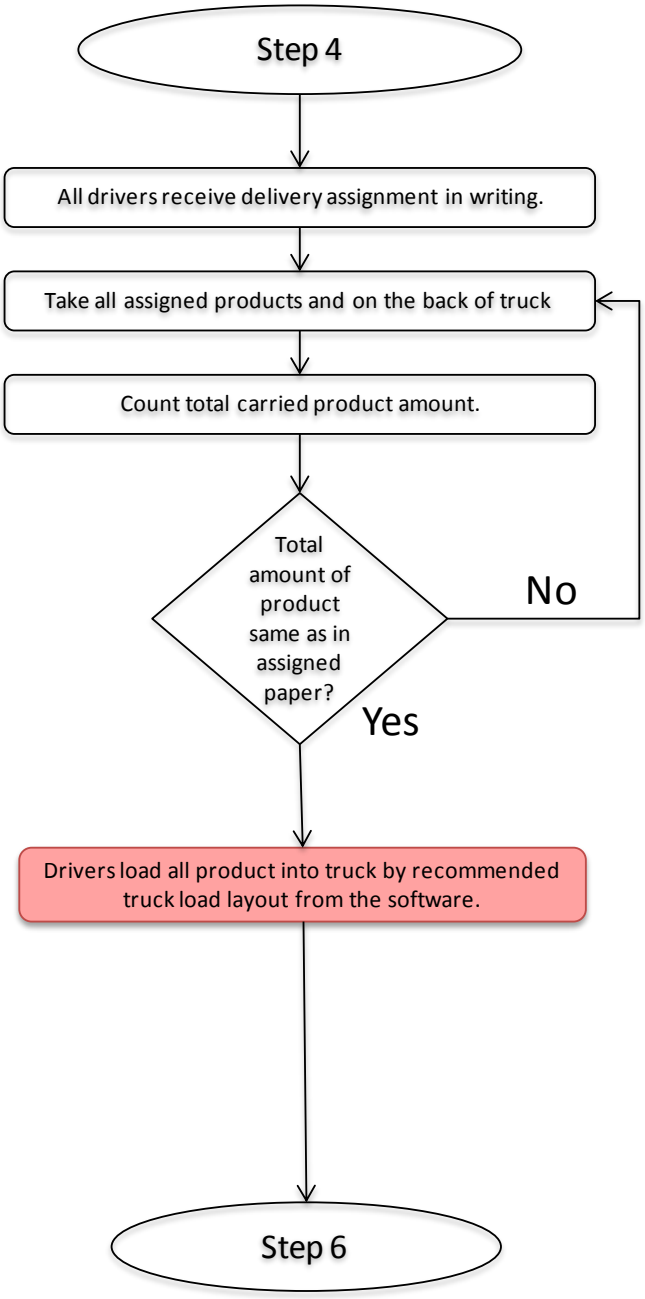


Figure 5.3 Proposed Adjustments in Step 5 – Truck Load

5.2 KPI Improvement for this case study

After applying the optimization framework with the case study, the optimization framework used PIs to compare the performance between current company transportation model and the new proposed transportation work flow. It is shown in Table 5.1.

Table 5.1 KPI Improvement

	Current Model(yearly)	**New Model (yearly)**	**Loss Saving (yearly)**	**PIs / KPI Improvement (yearly)**
Loss in Delivery Expense (PI)	327,302.04 Baht	143,220.75 Baht	184,081.29 Baht	56.24%
Sale Loss from Cut off (PI)	1 out of 7 times	0 time	235,872 Baht	100%
Profit Gain (KPI)			**419,953.29 Baht**	**5.45%**

CHAPTER VI
CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The case study tested with the adapted optimization framework for transportation in Manufacturer Company gave a good result of optimization. The optimization objective is to maximize company profit.

The first PI, Loss in Delivery Expense, was set as the case's PI. It was developed by linear programming formula. The goal was to minimize the Loss in Delivery Expense. The result of optimization suggested to use software called "CargoWiz" to generate the optimization truck load 3D layout in order to minimize the PI. It could improve the PI by 56.25% which could reduce the Loss in Delivery Expense about 184,081 Baht per year. In addition, minimizing this PI helped reducing the company expense.

The second PI, Sale Loss from Cut Off, was set as the case's PI. The goal was to minimize the Sale Loss from Cut Off. With the elimination of cut off strategy, the Sale Loss from Cut Off could reduce 235,872 Baht per year. The company could earn more on revenue. Moreover, it can increase company service level.

Combine both PIs could increase the KPI, which resulted in the gain of profit margin by 0.35% per year. So it is 5.45% KPI improvement.

It could be concluded that the adapted optimization framework for transportation could be applied to Manufacturer Company. The case study showed the result of optimization after applied with the research's optimization framework. The table 6.1 showed the adapted optimization framework.

Table 6.1 Different between Albright & Winston (2007)'s framework and adapted framework

Albright & Winston (2007)'s Framework	Adapted Framework for Transportation	Specification
Problem Definition	Problem Definition	Cost, Time Usage, Service Level.
Data Collection	Data Collection	
Model Development	Model Development	Define KPI with linear programming objective.
Model Verification	Model Verification	
Optimization and decision	Optimization	Use KPI to judge the efficiency
Model Communication	(Delete) It should communicate along the way.	Should do it from the beginning to the end as Albright & Winston (2007) suggested.
Model Implementation	Model Implementation	Propose only new transportation workflow

6.2 Usage of adapted framework

The proposed adapted framework can be used as a guideline for optimization for transportation. Any Manufacturer Company who has their own delivery service can apply this framework. All guideline steps from the adapted framework are strongly essential to pass all steps.

6.3 Limitation of adapted framework

The framework can be applied to only Manufacturer Company which has its own transportation system. It may apply to logistic company or any other business type. The optimization solution used only mathematical judgment. Some of KPIs might not be compatible with the research's optimization method.

The adapted framework can only be applied in the Perfect Competition business type. Most of the Manufacturer Company are in the perfect competition

business. Moreover, this framework has already tested with the case study which was in the perfect completion business.

6.4 Recommendations

The case study could demonstrate how the framework could improve the transportation system. It was because of the good cooperation of company. The accurate and adequate data and information are essential for this framework. The clear and profound data can help the optimization method to be successful and perform well.

6.5 Future Research

This research developed the adapted optimization specifically for transportation. The limitation of this framework was the optimization method. It was limited by using only mathematical model. The future research can study other optimization method rather than mathematical model. Manufacturer Business is not the only business who uses transportation, but also logistic, distributors, e-commerce, etc. It should be adapted more generic in any business type.

The adapted framework also can be developed more on applying to monopoly and oligopoly business type in Manufacturer Company for further case study.

The optimization method can be other solution rather than linear programming and optimization software. For example, redesigning the product carton dimension in order to fully fit on the truck space can reduce the unused space on the truck. It can be one of the optimization methods. The correct carton dimension can help to utilize the space in the truck more efficiently. The truckload layout does not need to be planned every time. So the future research can design the new standard carton dimensions for the company's truck dimensions. The truckload layout will be packed properly. In addition, new carton dimension may also lead to new product package design as well. This will help to fit product in the carton and the fit carton in the truck in the best way.

REFERENCES

Albright, C. S., & Winston, W. L. (2007). *Management Science Modeling.* Canada: South-Western Sengage Learning.

Balakrisnan, N., Render, B., & Stair, R. M. (2007). *Managerial decision modeling.* United State: Pearson International Edition.

Balinski, M. L. (1965). Interger Programming: Methods, Uses, Computation. *Management Science* , 253-313.

Birlin, E. G., Martinez, J. M., & Ronconi, D. P. (2005). Optimizing the packing of cylinders into a rectangular container. *European Approach* , 19-33.

Birlin, E. G., Martinez, J. M., Ronconi, D. P., & Mascarenhas, W. F. (2006). Method of Sentinels for Packing Items within Arbitrary Convex Regions. *The Journal of the Operational Research Society* , 735-746.

Charnes, A., & Cooper, W. W. (1963). Breakeven Budgeting and Programming to Goals. *Journal of Accounting Research* , 16-43.

Cooley, C. H. (1894). The Theory of Transportation. *American Economic Association* , 13-148.

Dantzig, G. B. (1963). *Linear Programming and Extensions*. Princeton University Press: The RAND Corporation.

Dyer, J. S. (1972). Interactive Goal Programming. *Management Science* , 62-70.

Gass, S. I. (1982). Decision-Aiding Models: Validation, Assessment,and Related Issues for Policy Analysis. *Operation Research* , 603-631.

Girvica, O. (2010). Modern Strategies for the costs optimization of the logistic center. *Scientific Journal of Riga Techical University* .

Kim, C. (1971). *Introduction to Linear Programming.* United State: Holt Renehart and Winston Inc.

Land, H. A., & Doig, G. A. (1960). An Automatic Method of Solving Discrete Programming Problems. *Econometrica* , 497-520.

Lederer, P. J., & Li, L. (1997). Pricing, Production, Scheduling, and Delivery-Time Competition. *Operation Research* , 407-420.

Mangasarian, O. L. (1964). Linear and Nonlinear Separation of Patterns by Linear Programming. *Shell Development Company* , 444-452.

Mangasarian, O. L. (1964). *Linear and NonLinear seperation of patterns by linear programming.* California: Shell Development Company.

Sery, S., Presti, V., & Shobrys, D. E. (2001). Optimization Models for restructuring BASF North America's Distribution System. *Interfaces* , 55-65.

Softtruck. (2007). *CargoWiz*. Retrieved 06 02, 2012, from CargoWiz by Softtruck: http://www.softtruck.com/

Stephen, G. P., & Kenneth, R. B. (2009). *Manangement Science.* United State: John Wiley & Sons.

Yavuz, A., Kadipasaoglu, S., & Schipperijn, P. (2010). A decision support framework for global supply chain modelling: an assessment of the impact of demand, supply and lead time uncertainties on performance. *International Journal of Production Research* , 3245-3268.

APPENDICES

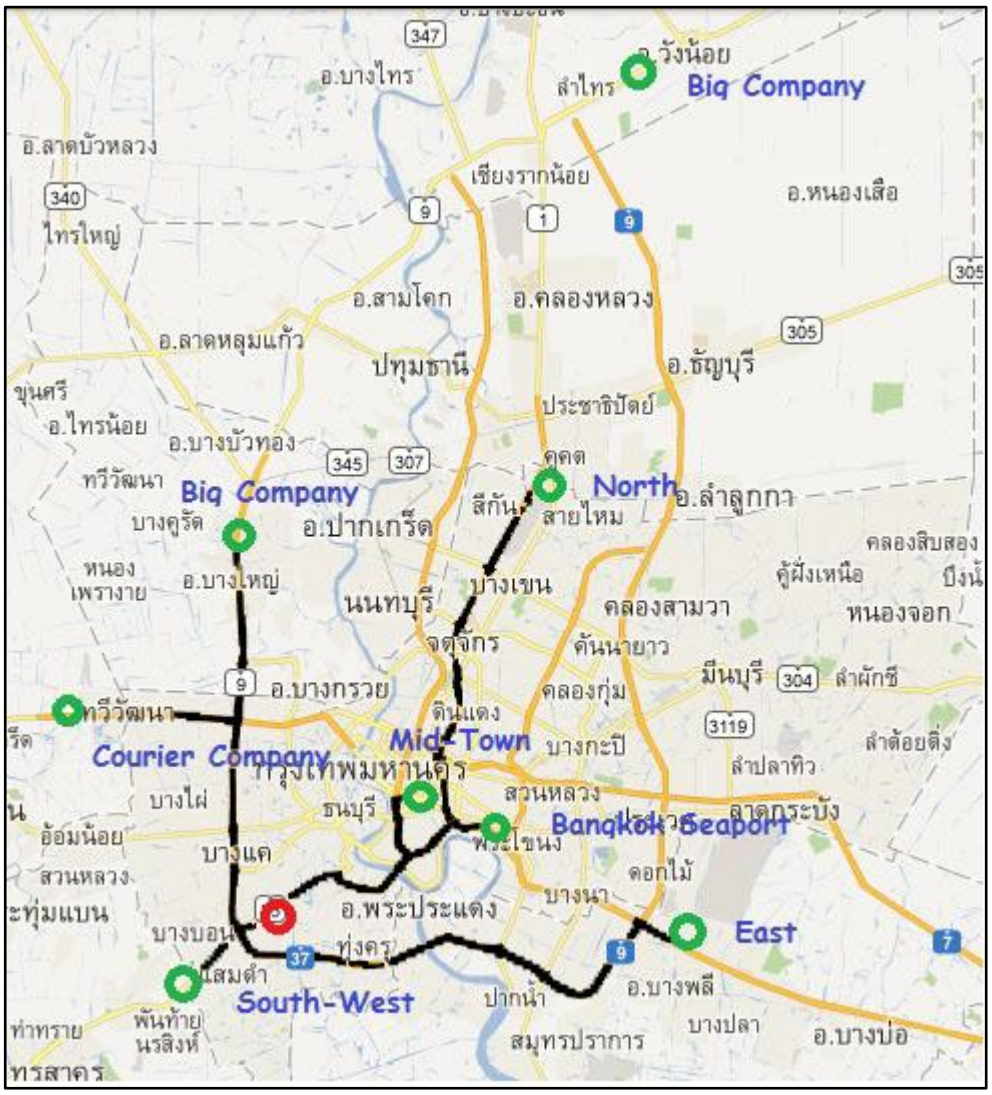
APPENDIX A

Table A: Zone Distance from Company

Zone No.	Zone location	Approximate Round trip Distance (km)
1	Mid-Town	32
2	South West	20
3	East	85
4	North	133
5	Bangkok Seaport	35
6	Courier Company	45
7	Big Company	58

APPENDIX B

Figure B: Zone location route map



The map above represents the zone location of the customers. The red point is the company base location. The green points are cluster zones of the customers which are located. The black lines are normal route of the truck.

APPENDIX C

Table C: Product Dimension

Product	Width (cm)	Length (cm)	Height (cm)	Capacity (sq.cm.)
A 189	30	41.25	21.25	26296.88
B 301	34.3	41.9	21.6	31042.87
C 55	24.37	41.87	20.30	20713.55
D 77	33.75	41.25	21.25	29583.98
E 777	38.12	41.25	21.25	33414.56
F 99	40	55	23.75	52250.00
G 37	32.5	32.5	46.25	48851.56
H 24	24.7	24.7	35.62	21731.41
I 30A	33.12	39.37	17.80	23210.03
J 646	41.25	41.25	27.50	46792.97
K Big Carton	40	70	67.5	189000.00

APPENDIX D

Table D : Truck Dimension

Product	Width (cm)	Length (cm)	Height (cm)	Capacity (sq.cm.)
6 Wheel Truck	225	550	230	28.46 M
4 Wheel Truck	170	310	175	9.22 M

APPENDIX E

Table E: Fuel Cost each Truck

Truck Type	Fuel Cost (Baht/km)	Labor Cost (Baht/Day)	Full Truck Load Time Usage (mins)	Average Extra Time if rearrange (mins)	Time Saving with layout guildeline(mins)
6 Wheels Truck	5.50	3 persons = 1020 Baht/Day	85 mins	21 mins	9 mins
4 Wheel Truck	3.80	2 persons = 700 Baht/Day	45 mins	14 mins	7 mins

Fuel Cost has been calculated from the historical truck fuel usage average in June 2012 from the company. It shows the fuel cost for each truck type as above.

APPENDIX F

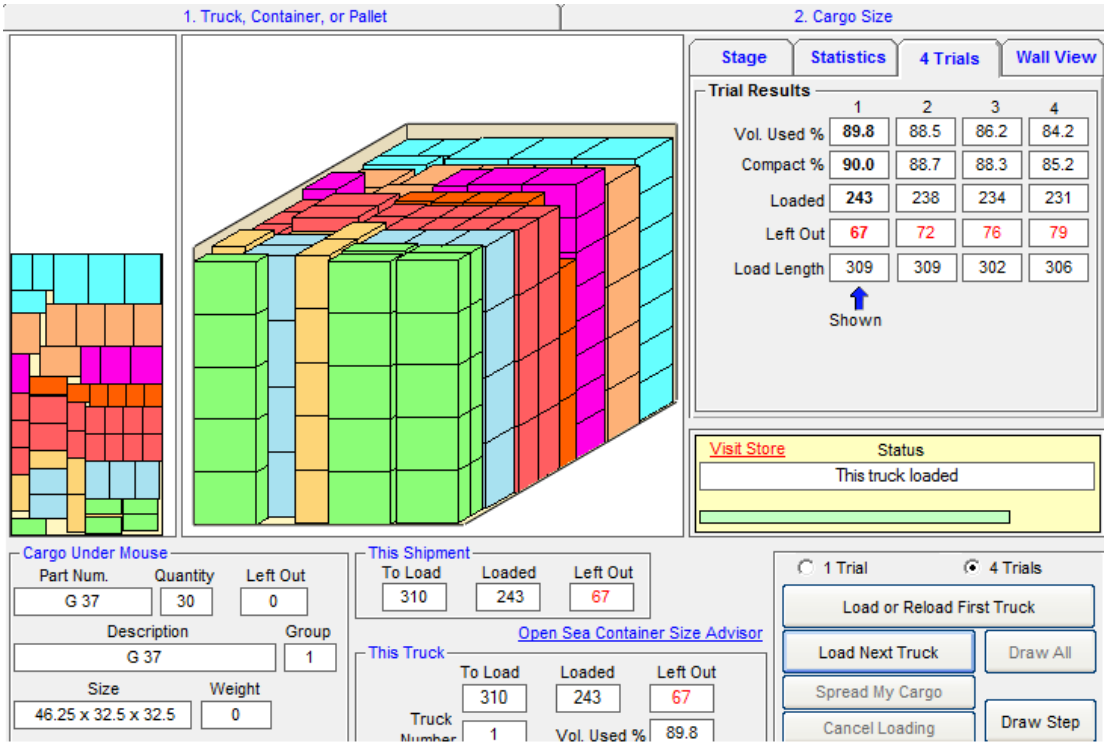


Figure F: CargoWiz simulation software

APPENDIX G

Table G: CargoWiz truck load simulation

No.	4 Whees Truck Simulation	Average(%)	6 Wheels Truck Simulation	Average(%)
1	90.70%	88.83%	92.60%	91.11%
2	90.10%	Unused Space	89.10%	Unused Space
3	92.60%	11.17%	89.70%	8.89%
4	87.70%		90.70%	
5	86.10%		94.70%	
6	85.50%		88.30%	
7	85.20%		94.60%	
8	91.20%		90.70%	
9	85.60%		92.10%	
10	86.00%		93.90%	
11	88.10%		93.20%	
12	91.80%		93.70%	
13	87.20%		89.10%	
14	91.70%		92.80%	
15	87.60%		87.40%	
16	92.50%		92.90%	
17	89.20%		92.30%	
18	92.80%		91.00%	
19	88.90%		91.20%	
20	91.60%		90.50%	
21	89.80%		93.00%	
22	90.50%		90.40%	
23	87.30%		92.80%	
24	86.00%		90.20%	
25	92.50%		91.30%	
26	92.20%		90.60%	
27	85.80%		89.10%	
28	91.80%		89.60%	
29	92.10%		89.10%	
30	89.80%		91.50%	
31	92.70%		88.50%	
32	86.60%		93.40%	
33	85.30%		92.80%	
34	91.80%		92.90%	
35	87.10%		89.80%	
36	85.10%		88.20%	
37	90.60%		89.00%	
38	91.80%		93.10%	
39	85.50%		93.00%	
40	85.70%		89.20%	
41	87.80%		93.40%	
42	88.90%		87.60%	
43	90.90%		91.90%	

Table G: CargoWiz truck load simulation (Continue)

44	86.70%		92.60%	
45	88.80%		87.40%	
46	87.00%		91.00%	
47	91.90%		87.70%	
48	86.90%		88.50%	
49	85.00%		93.30%	
50	88.50%		90.90%	
51	86.70%		94.00%	
52	85.40%		88.20%	
53	86.90%		91.10%	
54	86.10%		86.70%	
55	87.30%		93.30%	
56	92.80%		91.70%	
57	88.00%		92.40%	
58	85.70%		93.10%	
59	89.60%		90.80%	
60	87.20%		90.00%	
61	90.20%		90.10%	
62	91.60%		93.40%	
63	86.90%		91.70%	
64	92.80%		91.10%	
65	89.00%		88.30%	
66	90.40%		91.50%	
67	88.00%		92.80%	
68	86.10%		90.90%	
69	85.90%		93.10%	
70	92.30%		91.60%	
71	86.60%		88.60%	
72	88.40%		94.70%	
73	91.60%		89.30%	
74	90.30%		94.30%	
75	87.90%		89.50%	
76	85.20%		87.10%	
77	87.90%		93.20%	
78	88.90%		93.60%	
79	91.90%		94.00%	
80	85.00%		91.60%	
81	87.60%		89.30%	
82	90.70%		92.60%	
83	91.70%		85.50%	
84	87.60%		86.10%	
85	91.70%		91.00%	
86	89.70%		91.70%	
87	89.40%		93.20%	
88	86.00%		92.80%	
89	88.80%		94.50%	

Table G: CargoWiz truck load simulation (Continue)

88	86.00%		92.80%	
89	88.80%		94.50%	
90	85.80%		90.80%	
91	85.50%		91.90%	
92	91.10%		94.10%	
93	85.60%		88.50%	
94	92.40%		90.50%	
95	91.40%		91.80%	
96	92.90%		87.10%	
97	85.30%		89.00%	
98	91.80%		91.50%	
99	91.30%		94.10%	
100	89.60%		90.90%	

APPENDIX H

Table H: Cut Off Loss

Average amount of customers monthly	546 Customers
Cut Off	7 Customers
Cancellation	1 Customers
Average Revenue each PO	20,000 Baht / Order
Sale Loss monthly (%)	0.18%
Sale Loss Monthly	19,656 Baht
Sale Loss Yearly due to Cut Off	235,872 Baht

BIOGRAPHY

NAME	Arthit Charoenpitakchai
DATE OF BIRTH	5 Febuary 1984
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Kasetsart University, 2002-2006 Bachelor's Degree in Engineer (Computer Engineering) (Major: Computer) Mahidol University International College, 2010-2012 Master of Business Administration (Business Modeling and Analysis)
HOME ADDRESS	75 Soi Bangbon16, Bangbon1 Rd., Bangbon, Bangbon Bangkok 10150 Tel: 089 922 2527 E-mail: arthitbe@hotmail.com